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ORIGINAL ARTICLE

Attention and Memory Biases in Social Anxiety Disorder: The Role of Comorbid Depression

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Abstract Cognitive biases play an important role in the onset and maintenance of Social Anxiety Disorder (SAD). Few studies, however, have examined the role of comorbid Major Depressive Disorder (MDD) in the processing of emotional material. In addition, little is known about the relation among different cognitive biases. In the current study, 73 participants (54.79% female) completed an emotion face dot-probe task followed by a recognition memory test. Compared to participants with SAD, participants with comorbid SAD and MDD oriented away from supraliminally presented angry faces. Subsequently, SAD participants with and without comorbidity recognized fewer angry faces than non-disordered controls. Furthermore, attention biases for subliminally presented stimuli predicted recognition accuracy only for comorbid participants. These results suggest that the presence of comorbid MDD affects attentional orienting in SAD participants. In addition, it highlights the interconnectedness of attention and memory biases for comorbid participants.

Keywords Social anxiety disorder · Major depressive disorder · Comorbidity · Attention bias · Memory bias

Introduction

Cognitive theories posit that emotional disorders are associated with schema-congruent biases in the processing of emotional information, which in turn play an important role in the onset and maintenance of these disorders (Beck 1976; Mathews and MacLeod 2005). Cognitive theories further propose that these biases operate throughout all stages of information processing including perception, attention, memory and judgment. Individuals with Social Anxiety Disorder (SAD), for example, are expected to preferentially attend to socially threatening information and to exhibit enhanced memory for this information. Empirical evidence, however, does not consistently support these predictions (for a review see Mathews and MacLeod 2005). Whereas attention biases, for example, have been observed for subliminal or other short stimuli presentations, participants with SAD failed to show such biases when stimuli were presented for longer periods of time (e.g., Mogg et al. 2004). Even more surprising is the fact that the majority of studies have not provided evidence for a memory bias in socially anxious individuals (e.g., Becker et al. 1999; Cloitre et al. 1995; Rinck and Becker 2005).

In response to these inconsistent findings, researchers have proposed the vigilance-avoidance hypothesis (Mogg and Bradley 1998; Mogg et al. 1987), which states that anxious individuals are characterized by an initial hypervigilance when processing socially threatening material. Accordingly, SAD is associated with quick detection and immediate attention to relevant stimuli, even when stimuli are presented subliminally. Initial hypervigilance, however, is followed by attentional avoidance. Although some recent studies fail to support these propositions, (e.g., Mueller et al. 2009; Ononaiye et al. 2007), considerable evidence supports the vigilance-avoidance hypothesis. For example, individuals with SAD, compared to healthy controls, have been found to attend toward socially threatening stimuli presented for subliminal (7–14 ms; Mogg and Bradley 2002) or short presentation times (500 ms; e.g., Mogg et al.

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2004). When socially threatening stimuli were presented for longer durations (600 ms), however, participants with SAD disengaged their attention from these stimuli (e.g., Amir et al. 2003). Similar results have been obtained using both socially threatening words (e.g., Musa et al. 2003) and angry faces (e.g., Mogg et al. 2004). The vigilance-avoidance hypothesis suggests that SAD is characterized by fast orienting and detection of threat stimuli followed by avoidance of further processing of these stimuli (Mogg and Bradley 1998). Reduced elaboration of the socially threatening material due to this avoidance may provide an explanation for the lack of memory biases associated with SAD. Indeed, Hirsch et al. (2006) pointed out that cognitive biases do not operate in isolation but rather influence and interact with one another. Very few studies, however, have investigated multiple biases within the same group of participants and have examined the relation among these biases when examining the processing of emotional material in SAD.

In addition, few studies have investigated the role of comorbidity in cognitive processing of emotional material in social anxiety. SAD and Major Depressive Disorder (MDD) are highly comorbid, yet many studies either have excluded participants with comorbid depression or have included them but have not investigated whether biases differ in comorbid and non-comorbid subsamples (e.g., Maidenberg et al. 1996; Mogg et al. 2004). There is growing evidence that cognitive biases differ in participants diagnosed with anxiety disorders vs. participants diagnosed with MDD. For example, MDD is associated with enhanced memory for negative information (see Mathews and MacLeod 2005 for a review). In other studies, depressed individuals attended toward negative stimuli when material was presented for longer periods of time (e.g., Joormann and Gotlib 2007) but not when material was presented subliminally or for short presentation durations (Mogg et al. 1995). In their review of the literature, Mathews and MacLeod (2005) note no evidence of subliminal attention bias in depressed individuals even when samples have high comorbid anxiety rates. The authors speculate that the presence of comorbid depression may dampen attention toward emotional cues that might otherwise have been observed in anxiety disorders, and they highlight the need for future research to test this prediction. Participants with comorbid SAD and MDD compared to participants diagnosed with SAD may therefore differ in their processing of emotional material.

The first aim of the current study was to investigate attention biases in SAD compared to comorbid SAD and MDD (CMD). The second aim was to assess differences in memory biases between the SAD and CMD groups. The third aim was to examine the relation between attention and memory biases. A dot-probe task with emotional faces was used to investigate participants' attention toward subliminally and supraliminally presented happy, sad, angry, and disgusted facial expressions. Based on the vigilance avoidance hypothesis, it was predicted that SAD participants compared to control participants orient toward socially threatening faces in the subliminal condition and away from these stimuli in the supraliminal condition. In addition, based on Mathews and MacLeod's (2005) hypothesis that comorbid depression attenuates biases typically seen in anxiety disorders, it was predicted that CMD compared to SAD participants show less hypervigilance for socially threatening faces presented subliminally and less avoidance of socially threatening faces presented supraliminally. Following the dot-probe task, a recognition memory task was used to examine the second aim of the current study, which explored group differences in the ability to recognize emotional facial stimuli. Participants diagnosed with SAD compared to control participants were expected to exhibit impaired memory for socially threatening stimuli. However, based on observations of increased elaboration of negative material and enhanced memory for these materials in MDD, CMD compared to SAD participants were expected to exhibit improved memory for socially threatening stimuli. Finally, the third goal of the current study was to investigate the relation between attention and memory biases. Attention and memory biases were expected to be associated. It was hypothesized that the more participants orient away from the socially threatening faces in the supraliminal condition, the poorer their memory for these faces. This association was also examined in each group separately; however, no a priori hypothesis was made about group differences.

Method

Participants

Participants were recruited via newspaper advertisements and Internet postings. Adults between 18 and 60 years of age who were fluent in English were screened over the phone for initial exclusion/inclusion criteria. Individuals who had experienced severe head trauma, had learning disabilities, psychotic symptoms, or met DSM-IV criteria for bipolar disorder or for alcohol or substance abuse within the past 6 months were excluded. An abbreviated version of the Structured Clinical Interview for the DSM-IV (SCID; First et al. 1995) was used during phone interviews to identify participants who were likely to meet criteria for inclusion into one of three groups: (1) individuals who met DSM-IV criteria for current SAD but not MDD (SAD); (2) individuals who met DSM-IV criteria for current SAD *and* MDD (CMD); or (3) individuals who did not meet criteria for any past or current Axis I disorder (CTL). Individuals expected to meet inclusion criteria were invited to participate in the SCID (First et al. 1995), which was administered in the laboratory by trained and experienced graduate-student interviewers. Based on the SCID, 73 individuals (25 SAD, 15 CMD, and 33 CTL) were deemed eligible and were included in the study.

Dot-Probe Task

Stimuli

Faces were selected from the (Tottenham et al. 2002) MacArthur Network Face Stimuli Set[1] (http://www.macbrain.org/faces/index.htm), developed by The Research Network on Early Experience and Brain Development. The entire MacArthur Network Face Stimuli Set consists of 646 different photographs of facial expressions depicted by a variety of male and female models of different ethnicities. For the current study, 10 male and 10 female faces were selected, each depicting a neutral, happy, sad, angry, and disgusted expression. Fourteen of the models were Caucasian and six were African American. Pictures of two additional Caucasian models depicting fear were used during the practice trials. All pictures were cropped just below the chin, above the hairline, and at the start of each ear. The mask that was used consists of a cut-up and randomly assembled picture of a neutral face (as used by Mogg and Bradley 1999). Pictures were approximately 8 cm × 10 cm in size, and each pair was presented in black-and-white approximately 14 cm apart (measured from their centers).

Design

A picture of each model depicting an emotional expression was paired with a picture of the same model depicting a neutral expression. Using E-Prime software, each of these picture pairs was presented four times subliminally and four times supraliminally, for a total of 640 trials, which were divided into four blocks. Every block contained 80 subliminal trials and 80 supraliminal trials, and within each block, the trials were presented in a fully randomized order for each subject. All trials began with the display of a white fixation cross in the middle of the screen for 1,000 ms, followed by the presentation of a picture pair (one emotional expression and one neutral expression). For subliminal trials, the picture pair was displayed for 7 ms and was immediately followed by the mask, which was presented for 186 ms (as has been used in previous studies, e.g., Bradley et al. 1997). For supraliminal trials, the picture pair was displayed for 1,000 ms. Following the offset of the pictures (or the mask), a small white dot (*) appeared centered in the location of one of the pictures and remained on the screen until the participant pressed the keyboard indicating the side of the screen (right or left) the dot was located. Faces with emotional expressions (happy, sad, angry, or disgusted) appeared with equal probability in the right and left position, with the matched neutral face of each pair appearing in the other position. Similarly, the dot probe appeared with equal probability in the left and right position and with equal probability behind the emotional and neutral face.

Participants were told that they should detect the dot as quickly and accurately as possible. They were informed that the dot could appear in the left or right position on the screen. Responses were made by pressing the key labeled "L" (the n key on a standard keyboard) if the dot appeared on the left or "R" (the m key on a standard keyboard) if the dot appeared on the right. Participants completed 10 practice trials of the dot-probe task with the experimenter present in the room before going onto complete four blocks of 160 trials on their own. In between each of the four blocks participants were given a 30 s break.

Distractor Task

To avoid recency effects (Broadbent and Broadbent 1981), participants were administered a distractor task after participating in the dot-probe task and prior to the memory task. The digit symbol-coding task from the Wechsler Adult Intelligence Scale-Third Edition (Wechsler 1997) served as the distractor. Standard administration instructions were followed.

Recognition Task

Stimuli

Eighteen of the twenty models that were presented in the dot-probe task were paired with 18 novel models depicting identical emotional expressions. These 18 pairings were matched on gender, ethnicity, and emotional expression, thereby creating 72 pairs, four pairs for each individual (one in each of the four emotional expressions: happy, sad, angry, and disgusted). The remaining two models, African American female models, were unable to be paired with

[1] Development of the MacBrain Face Stimulus Set was overseen by Nim Tottenham and supported by the John D. and Catherine T. MacArthur Foundation Research Network on Early Experience and Brain Development. Please contact Nim Tottenham at tott0006@tc.umn.edu for more information concerning the stimulus set.

models who matched across all characteristics and were instead paired with two novel male models. These pairings were used only in the practice trials. Pictures were cropped in an identical format as in the dot-probe task. They were approximately 12 cm × 15 cm in size and each pair was presented in black-and-white approximately 16.5 cm apart, as measured from their centers.

Design

Each of the 72 picture pairs was presented on the computer screen using E-Prime software. Trials began with a black fixation cross presented for 500 ms and were followed by the presentation of the picture pairs. One picture depicted a model that had been presented in the previous dot-probe task, and the other picture depicted a completely novel face that had never been presented during the experiment. Participants were given 3 s to indicate which face had been seen in the previous dot-probe task by pressing a key on the keyboard. At the end of the 3 s, the computer automatically progressed to the next trial, regardless of whether the participant provided a response. The familiar face appeared with equal probability in the right and left position, with the novel face appearing in the other position. Trials were presented in random order.

The experimenter read the instructions out loud, which explained to participants that their job was to identify which of the two pictures had been seen in the prior computer task (the dot-probe task). Participants were asked to press the key labeled “L” (the n key on a standard keyboard) if the familiar face was the one on the left, or to press the key labeled “R” (m key on a standard keyboard) if the familiar face was the one on the right. They were told that there would never be two new faces or two familiar faces. The experimenter also informed participants of the 3-second time limit in which to make the selection. Participants then completed the 72 trials.

Awareness Check

Stimuli

The awareness task was comprised of the same pictures of the 10 male and 10 female models that were used in the dot-probe task. Each picture was paired with a photograph of the same model displaying the same emotional expression. The pairs only differed in that if the original picture depicted an open-mouthed expression, the pair depicted a close-mouthed expression (e.g., sad + open-mouthed was paired with sad + close-mouthed). The 20 picture-pairs were presented four times in the awareness check task, once in each of the four emotional expressions (happy, sad, angry, and disgusted). Pictures were cropped and presented in a format identical to that in the dot-probe task.

Design

In line with past studies (e.g., Mogg and Bradley 2002), participants completed the awareness check to ensure that the pictures presented subliminally (for 7 ms) during the dot-probe task were indeed presented below participants’ awareness threshold. Picture pairs were presented on the computer screen using E-Prime software in an identical manner to that used during subliminal trials of the dot-probe task. Specifically, trials began with a white fixation presented for 495 ms against a black background and were followed by the picture-pairs presented side-by-side on the computer screen for 7 ms. Both pictures were then immediately replaced by the same mask that was used in the dot-probe task, which was presented for 186 ms. Participants were then asked to indicate whether the pictures were of a man or a woman.

Once again, the experimenter read the instructions out loud. Participants were instructed to press the key labeled “M” (the 7 key on a standard keyboard) if the face on the screen was a man or press the “W” (the 8 key on a standard keyboard) if the face on the screen was a woman. They completed 80 trails.

Questionnaires

BDI

Participants completed the Beck Depression-Inventory-II (BDI-II, Beck et al. 1996), a 21-item self-report measure to assess depression severity at the time when the computer tasks were completed. Respondents report how much they have been bothered by depression symptoms on a four-point scale. This measure has shown excellent reliability and validity (Beck et al. 1996). In the current study, there was good internal consistency ($\alpha = .96$) and mean inter-item correlations ($r = .57$).

LSAS

The Liebowitz Social Anxiety Scale (Liebowitz 1987) was also completed by all participants. The LSAS is a 24-item self-report measure of the extent that individuals experience fear/anxiety and avoidance about a number of social anxiety provoking situations. This scale has shown excellent reliability and validity (Baker et al. 2002). In the current study, there was good internal consistency ($\alpha = .95$) and mean inter-item correlations ($r = .44$).

Procedure

All participants took part in the phone interview and the SCID, which took approximately 2 h. Following the SCID, eligible participants were scheduled for their second session within 2 weeks. In the second session, participants completed the dot-probe task, distractor, recognition task, awareness check, and questionnaires in that order. The attention, recognition, and awareness tasks were presented on an IBM-compatible computer and an Acer 12- × 17-in color monitor using E-Prime software to control stimulus presentation and record response accuracy and latency.

Statistical Analyses

To test the hypothesis that groups differ in their attention to emotional facial expressions presented subliminally vs. supraliminally, a three-way Group (SAD, CMD, CTL) by Emotion (happy, sad, angry, disgusted) by Duration (subliminal, supraliminal) repeated-measures analysis of variance (ANOVA) was conducted on attention bias scores from the dot-probe task. To test the hypothesis that groups differ in their memory of emotional facial expressions, participants' accuracy during the recognition task was examined. A two-way Group (SAD, CMD, CTL) by Emotion (happy, sad, angry, disgusted) repeated-measures ANOVA was conducted on the percentage of correct responses. To test the hypothesis that attention and memory biases are associated, correlations were examined among attention bias scores from the dot-probe task and percentage of correct responses in the recognition task.

Results

Participant Characteristics

Demographic and clinical characteristics of the three participant groups are presented in Table 1. The proportion of women was similar across groups, $\chi^2(2, N = 73) = 2.29$, $P > .05$. The three groups did not significantly differ in ethnicity, $\chi^2(10, N = 73) = 13.70$, $P > .05$; however, groups did differ in age, $F(2, 70) = 4.55$, $P < .05$, $\eta^2 = 0.12$: CMD participants were older than SAD participants, $t(38) = 3.20$, $P < .01$, $r^2 = 0.21$. CTL participants, however, did not differ from SAD participants, $t(56) = 1.75$, $r^2 = 0.05$, or from CMD participants, $t(46) = 1.56$, $r^2 = 0.05$, both $P > .05$. In addition, there was the anticipated significant difference in participants' BDI scores, $F(2, 70) = 42.93$, $P < .001$, $\eta^2 = 0.55$, with SAD participants obtaining significantly lower BDI scores than the CMD participants, $t(38) = 3.49$, $P < .01$, $r^2 = 0.24$. CTL participants also obtained significantly lower BDI scores than SAD, $t(56) = 6.10$, $P < .001$, $r^2 = 0.40$, and CMD participants, $t(46) = 9.75$, $P < .001$, $r^2 = 0.67$. As expected, there was a significant difference in LSAS scores, $F(2, 65) = 62.72$, $P < .001$, $\eta^2 = 0.66$.[2] CTLs obtained significantly lower LSAS scores than the SAD, $t(52) = 9.96$, $P < .001$, $r^2 = 0.66$, and CMD groups, $t(41) = 10.17$, $P < .001$, $r^2 = 0.72$; however, SAD and CMD participants did not differ in their LSAS scores, $t(37) = 0.92$, $P > .05$, $r^2 = 0.02$.

At the time of testing, 12 of the participants in the SAD group also met DSM-IV criteria for another anxiety disorder (six for Panic Disorder, two for Specific Phobia, two for Obsessive Compulsive Disorder, two for Post Traumatic Stress Disorder, and four for Generalized Anxiety Disorder). Similarly, within the CMD group, eight participants met criteria for another anxiety disorder (four for Panic Disorder, one for Agoraphobia without Panic Disorder, five for Specific Phobia, three for Post Traumatic Stress Disorder, and two for Generalized Anxiety Disorder).

Awareness Check

A two-way Group (SAD, CMD, CTL) by Emotion (happy, sad, angry, disgusted) repeated-measures analysis of variance (ANOVA) was conducted on response accuracy. Neither the main effect of Group, $F(2, 70) = 0.14$, $P > .05$, $\eta^2 = 0.004$, nor the main effect of Emotion, $F(3, 210) = 1.45$, $P > .05$, $\eta^2 = 0.02$, was significant. In addition, the Group by Emotion interaction did not reach significance, $F(6, 210) = 0.47$, $P > .05$, $\eta^2 = 0.01$. Accordingly, the percentage of accurate responses was similar across groups for all four emotional expressions. Furthermore, a one-sample *t*-test revealed that the mean accuracy for the happy, sad, angry, and disgusted conditions (44.45, 50.27, 47.95, and 50.48% respectively) did not differ from chance, $t(72) = 1.70$, 0.25, 1.86, and 0.46, all ns, $r^2 < 0.05$.

Dot-Probe Task

To examine group differences in performance during the dot-probe task, only response latencies from correct responses were examined. Error rates were low (<5% across all participants) and did not differ among the groups, $F(2, 70) = 1.52$, $P > .05$, $\eta^2 = 0.00$. Average reaction times were computed for each group separately for each emotion type in each of the conditions (i.e., probe in *same* location as emotional face [same] vs. probe in *opposite* location as emotional face [opposite]). To test specific

[2] LSAS data are missing for five participants (one CMD and four CTL).

Table 1 Participant characteristics

Variable	Group			
	SAD	CMD	CTL	
N	25	15	33	
Age (SD)	31.76 (10.66)	42.93 (10.75)	37.15 (12.33)	$F(2, 70) = 4.55^{**}$
% Men	40.00	33.33	54.55	$\chi^2(2, N = 73) = 2.29$
% Caucasian	28.00	20.00	18.18	$\chi^2(10, N = 73) = 13.70$
BDI (SD)	16.12 (9.87)	28.53 (12.48)	3.94 (5.11)	$F(2, 70) = 42.93^{***}$
LSAS (SD)	82.76 (25.25)	90.50 (25.08)	25.93 (16.28)	$F(2, 65) = 62.72^{***}$

Note: *SAD* social anxiety disorder, *CMD* comorbid social anxiety disorder and major depressive disorder, *CTL* control, *BDI* beck depression inventory—II, and *LSAS* Liebowitz social anxiety scale

** $P < .01$, *** $P < .001$

hypotheses, attention bias scores were computed for each facial expression (happy, sad, angry, and disgusted), using the following equation (cf. Mogg et al. 1995):

$$\text{Attention bias score} = \tfrac{1}{2}[(\text{R.Same} - \text{R.Opposite}) + (\text{L.Same} - \text{L.Opposite})]$$

where R indicates that the probe appeared on the right and L indicates that it appeared on the left. Therefore, R.Same indicates the mean reaction time when the prime was in the right and the emotional face was in the same location. According to this formula, positive attention bias scores indicate a tendency to shift attention toward the emotional face relative to the matched neutral face. Conversely, negative attention bias scores indicate a tendency to shift attention away from the emotional face in favor of the matched neutral faces.

The three-way Group (SAD, CMD, CTL) by Emotion (happy, sad, angry, disgusted) by Duration (subliminal, supraliminal) repeated-measures ANOVA yielded a significant three-way interaction, $F(6, 210) = 2.64$, $P < .05$, $\eta^2 = 0.07$. Follow-up analyses revealed no significant Group by Duration interaction for happy, $F(2, 70) < 1$, $\eta^2 = 0.02$; sad, $F(2, 70) = 1.69$, $P > .05$, $\eta^2 = 0.05$; or disgusted emotional expressions, $F(2, 70) < 1$, $\eta^2 = 0.02$. However, a Group by Duration interaction was found for angry emotional expressions, $F(2, 70) = 3.54$, $P < .05$ $\eta^2 = 0.09$. Although SAD participants did not significantly differ from controls in their attention toward angry emotional expression presented subliminally or supraliminally, $t(56) = 0.26$ and $t(56) = 0.55$ respectively, both $P > .05$, $r^2 = 0.00$, there was a significant difference between SAD and CMD participants' attention toward angry emotional expressions presented supraliminally, $t(38) = 2.27$, $P < .05$, $r^2 = 0.12$. CMD participants, but not SAD participants, attended away from angry facial expressions presented for 1,000 ms; see Fig. 1. There was no difference between SAD and CMD participants' attention subliminally, $t(38) = 1.23$, $P > .05$, $r^2 = 0.04$, or between CTL

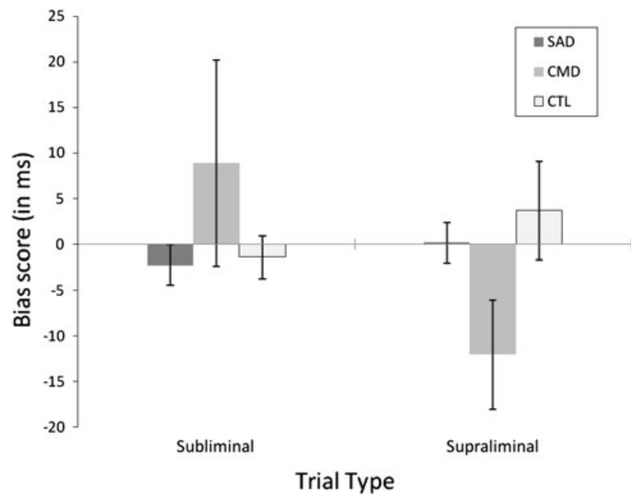

Fig. 1 Attention bias scores for angry faces presented subliminally and supraliminally in participants with social anxiety disorder (*SAD*), comorbid social anxiety and major depressive disorder (*CMD*), and controls (*CTL*). *Error bars* represent ± 1 standard error

Fig. 2 Percent of previously seen angry, disgusted, happy, and sad faces correctly recognized by participants with social anxiety disorder (*SAD*), comorbid social anxiety and major depressive disorder (*CMD*), and controls (*CTL*). *Error bars* represent ± 1 standard error

and CMD participants' attention subliminally or supraliminally, $t(46) = 1.25$ and $t(46) = 1.76$ respectively, both $P > .05$, $r^2 < 0.07$. Covarying age did not change the finding: the Group by Emotion by Duration interaction remained significant, $F(6, 207) = 2.66$, $P < .05$, $\eta^2 = 0.07$.[3]

Recognition Task

The two-way Group (SAD, CMD, CTL) by Emotion (happy, sad, angry, disgusted) repeated-measures ANOVA yielded no significant main effects for Group, $F(2, 70) = 1.16$, $P > .05$, $\eta^2 = 0.03$ or for Emotion, $F(3, 210) = 0.33$, $P > .05$, $\eta^2 = 0.01$. This analysis, however, yielded a significant Group by Emotion interaction, $F(6, 210) = 3.10$, $P < .01$, $\eta^2 = 0.08$. Follow-up analyses indicated that significant group differences were not observed for faces displaying happy, sad, or disgust emotional expressions, all $F(2, 70) < 1$; however, significant group differences were found for faces displaying angry emotional expressions $F(2, 70) = 4.09$, $P < .05$, $\eta^2 = 0.10$. CTL participants ($M = 82.85\%$, SD = 9.27) remembered significantly more faces displaying angry expressions than did SAD ($M = 70.72\%$, SD = 22.09), $t(56) = 2.85$, $P < .01$, $r^2 = 0.13$, and CMD participants ($M = 71.73\%$, SD = 22.30), $t(46) = 2.46$, $P < .02$, $r^2 = 0.12$; see Fig. 2. SAD and CMD groups, however, did not differ, $t(38) = 0.14$, $P > .05$, $r^2 = 0.00$. Covarying age did not change the finding: the Group by Emotion interaction remained significant, $F(6, 207) = 3.41$, $P < .01$, $\eta^2 = 0.09$.

Correlation Between Attention and Memory

Across all participants, biased attention for subliminally presented faces displaying angry emotional expressions were negatively associated with accurate recognition of faces displaying happy, sad, angry, and disgusted emotional expressions (see Table 2). No other bias score was significantly associated with participants' performance on the recognition task. Correlations among attention bias scores and recognition accuracy were also examined separately for each group. No significant correlations were found for the SAD or CTL groups when examined individually. In the CMD group, however, attention for subliminally presented faces displaying angry emotional expressions were negatively associated with memory for faces displaying happy, sad, angry, and disgusted emotional expressions, $r(13) = -.61$, $-.53$, $-.56$, and $-.62$, respectively, all $P < .05$. In addition, attention for subliminally presented faces displaying sad emotional expressions were positively associated with memory for faces displaying sad emotional expressions in this group, $r(13) = .55$, $P < .05$.[4]

Table 2 Correlations among attention bias scores and recognition accuracy for all participants

Attention bias scores by emotion and presentation time	Recognition accuracy			
	Happy	Sad	Angry	Disgusted
Subliminal				
Happy	−.13	−.08	.02	.02
Sad	−.02	.06	.14	.06
Angry	−.33**	−.29*	−.28*	−.31**
Disgusted	−.02	−.03	.01	.01
Supraliminal				
Happy	.03	−.04	.00	.11
Sad	−.12	−.09	−.09	−.04
Angry	.03	.11	.13	.07
Disgusted	−.01	.02	.08	.01

Note: $n = 73$

* $P < .05$, ** $P < .01$

Discussion

The current study was designed to examine whether participants diagnosed with comorbid SAD and MDD (CMD) differ from participants diagnosed with only SAD in their attention to and memory for facial expressions of emotion. In addition, the current study examined the relation among attention and memory biases. CMD participants, compared to SAD participants, oriented away from angry faces presented for 1,000 ms. No other attention biases were obtained in the dot-probe task. In the subsequent recognition task, SAD participants with and without comorbid MDD exhibited poorer memory for angry faces compared to control participants. In addition, a significant correlation was obtained among attention biases in the processing of angry faces and memory for facial expressions of emotion in the CMD group only. The more CMD participants attended toward angry faces presented subliminally, the fewer number of faces were recognized in the subsequent

[3] Using log-transformed bias scores and covarying age, the Group by Emotion by Duration interaction was marginally significant at the $\alpha = .07$ level, $F(6, 207) = 2.00$, $P = .066$, $\eta^2 = 0.06$.

[4] Correlations among the log-transformed attention bias score for angry faces presented subliminally and memory for happy, sad, angry, and disgusted faces remains across all participants, $r(71) = -.29$, $-.24$, $-.24$, and $-.26$, respectively, all $P < .05$. Within the comorbid group, the correlations between the log-transformed attention bias score for angry faces presented subliminally and memory for happy, sad, angry, and disgusted faces also remains, $r(13) = -.62$, $-.52$, $-.57$, and $-.62$, respectively, all $P < .05$. Log-transformed attention bias score for subliminally presented sad faces was also correlated with memory for sad faces, $r(13) = .64$, $P < .05$.

memory task. In contrast, the more CMD participants attended toward sad faces presented subliminally, the more likely they were to recognize sad faces. In sum, this study provides important evidence that participants diagnosed with SAD differ from CMD participants in their processing of emotional material and for the proposition that an association exists among attention and memory biases.

Contrary to predictions from the vigilance-avoidance hypothesis, SAD participants in the current study did not attend toward socially threatening stimuli presented subliminally nor did they attend away from such stimuli presented supraliminally. Even though these findings were unexpected, there is a growing body of literature that reports similar results. A lack of attention biases for briefly or subliminally presented stimuli in socially anxious participants has been found in both clinically diagnosed (Mueller et al. 2009) and analogue samples (Bradley et al. 1997; Mansell et al. 1999; Mansell et al. 2002; Ononaiye et al. 2007; Pineles and Mineka 2005). In addition, in studies that have obtained evidence for attention biases in SAD, the directionality has been mixed, even when facial stimuli were used. Mansell and colleagues (Mansell et al. 1999), for example, reported that high compared to low socially anxious individuals attended away from emotional faces. Sposari and Rapee (2007), however, found the opposite pattern despite an explicit attempt to replicate Mansell et al.'s findings. Therefore, unlike other anxiety disorders, SAD appears not to be consistently associated with hypervigilance for threatening information. It could be, however, that the lack of attention bias found in the current study was a result of the study design. Ononaiye et al. (2007) recently proposed that repeated exposure to threatening stimuli during these kinds of cognitive tasks could result in habituation and in turn decreased hypervigilance of the attentional system. Indeed, work by Luecken et al. (2004) suggests that repeated presentation of supraliminal threatening stimuli reduces attention focus in the subliminal trials. In the current study, participants were exposed to more supraliminal trials than previous studies that reported initial hypervigilance (e.g., Mogg and Bradley 2002; Mogg et al. 2004). It is therefore possible that the choice to examine multiple threatening emotional expressions (disgust, anger), resulted in increased subliminal trials, and inadvertently led to habituation. Future studies are needed to further investigate this possibility. With regards to SAD participants' performance during supraliminal trials, only a handful of studies have investigated attention biases for stimuli presentations beyond 500 ms in SAD. In line with the current study, other studies reported no attention bias in participants diagnosed with SAD (Mogg et al. 2004). In contrast, one study using eye tracking technology instead of the dot-probe task obtained evidence for attentional avoidance in an analogue sample (Wieser et al. 2009). Wieser and colleagues found that high socially anxious individuals attended toward neutral and away from angry faces in the time interval from 1,000 to 1,500 ms. Future work is needed to better understand the time course of attention biases in SAD.

Although CMD and SAD participants did not differ in their attention toward faces presented subliminally, the groups did differ in their attention toward angry facial expressions presented supraliminally. Compared to SAD participants, CMD participants oriented away from angry faces presented for 1,000 ms. This pattern of attentional avoidance at longer stimuli durations is similar to the one reported by Wieser et al. (2009), whose analogue sample of high socially anxious individuals did not exclude for depressive symptoms or diagnosis. The difference between CMD and SAD groups suggests that comorbidity is an important consideration in studies investigating attention biases in SAD and may contribute to the increased symptom severity often seen in comorbid participants (Rosenbaum et al. 1996). Indeed, biases that had been expected in the SAD group were only present in the CMD group. These results add to a growing literature that demonstrates that comorbid MDD affects cognitive processing of emotional material in participants with anxiety disorders (e.g., Grant and Beck 2006; Musa et al. 2003). Some of the inconsistent findings in studies on cognitive biases in SAD may be related to a lack of attention to the role of comorbid conditions. This possibility underscores the need to carefully screen or control for comorbidity.

In agreement with predictions from the vigilance-avoidance hypothesis, SAD participants exhibited poorer memory for angry facial expressions. Multiple types of memory exist, and the current study focused only on participants' ability to recognize facial expressions. Although consistent with past research that found individuals with SAD to show poorer memory for negative stimuli compared to non-anxious controls (e.g., Perez-Lopez and Woody 2001; Wenzel and Holt 2002), the literature on memory biases in SAD is quite mixed. Some studies have found no difference between socially anxious and control participants' memory for threatening stimuli (e.g., Cloitre et al. 1995; Lundh and Ost 1996a; Rapee et al. 1994), yet other studies report individuals with SAD to have better memory for threatening stimuli (e.g., Amir et al. 2000). Such discrepancies might be due to the way in which the material was initially encoded. In studies that have found SAD participants to have better memory for threatening compared to accepting faces (e.g., Lundh and Ost 1996b), encoding tasks required participants to attend equally to neutral, negative, or positive stimuli. In contrast, the encoding task used in the current study allowed participants to control the amount of time they initially attended towards socially threatening faces.

Contrary to expectations, the current study found that CMD participants exhibited poorer memory for angry faces compared to CTL participants; however, the CMD and SAD groups did not significantly differ from one another. Although enhanced memory in the CMD compared to SAD group was hypothesized based on observations of increased elaboration of negative material in MDD, the design of the current study may have prevented the typical pattern of elaboration. An important difference between the current study and past designs is the activity of individuals after encoding. Participants in the current study were asked to engage in a distracting, cognitive task during the 5 min between the dot-probe (encoding) and recognition tasks, which may have hindered elaborative post-event processing styles. Post-event processing has been shown to influence participants' memory for subsequent material, with ruminative or elaborative processing associated with enhanced recall of negative material (e.g., Mellings and Alden 2000; Morgan and Banerjee 2008). The use of a distracting, cognitive task in the current study may have contributed to the fact that CMD participants did not show increased memory for negative material.

The current study demonstrated important connections between attention and memory biases. When broken down by group, CMD participants were the only group to show significant correlations among attention and memory biases for emotional facial expressions. Importantly, these findings are consistent with the vigilance-avoidance hypothesis in that the more participants oriented towards subliminally presented angry faces, the less likely they were to recognize angry faces in the subsequent memory task. The current findings also support the likelihood that cognitive biases are interconnected, as has been postulated by Hirsch and colleagues (Hirsch et al. 2006). Future studies should continue to explore the way in which cognitive processes interact and influence one another. The correlation between attention toward angry faces and poorer recognition of the other emotional expressions (happy, sad, and disgusted), however, was unexpected. This correlation may reflect a general avoidance of emotional expressions in people with CMD who are highly sensitive to detect anger.

The current study has several limitations that are important to note. For one, clinical participants in the current sample had several comorbid conditions including the presence of other anxiety disorders, which may have affected their interpretation or processing of emotional faces. Future work is needed to better understand the role of other comorbid anxiety disorders. A second limitation is the fact that a group with only MDD was not included. We, therefore, cannot rule out that differences between the SAD and CMD groups are due to depression alone. An additional limitation is that participants in the current study were diagnosed with other comorbid disorders, such as panic disorder. Because the presence of comorbidity might affect cognitive biases, future research should focus on samples without extra comorbid conditions. A fourth limitation is that only Caucasian and African American models were used in the facial stimuli. This restricts the generalizability of the current findings, and future work might select more ethnically diverse facial stimuli. In addition, the dot-probe task has been criticized because it assesses attention at only specific points in time. As such it is difficult to accurately measure initial orienting and later disengagement. Using eye tracking, recent studies have provided an alternative method of examining the time course of attention biases (e.g., Wieser et al. 2009). Interestingly, however, studies suggest some convergence among dot-probe and eye-tracking studies (Mogg et al. 2000). It would therefore be important for future work to investigate additional exposure durations or to incorporate eye tracking. A power analysis based on the effect size of $d = .85$, which was calculated from Musa et al.'s (2003) comparison of SADs and CTLs, suggests that a sample of 44 participants was required in order to detect differences between the two groups at $\alpha = .05$ and power = 85%. This implies that the current study had sufficient power to detect differences between SADs and CTLs. Using the effect size from Musa et al.'s (2003) comparison of SADs and CMDs ($d = .78$), a power analysis indicated that a sample of 50 participants was required in order to detect differences between the two groups at $\alpha = .05$ and power = 85%. It is therefore possible that the lack of group differences between SAD and CMD participants' subliminal attention toward and memory for emotional material was due to insufficient power in the current study. Future studies might consider replicating these results with a larger sample size.

In sum, these results add to the literature in two important ways. The current study provides first evidence for an association among different cognitive biases, specifically attention and memory. A better understanding of the relation among cognitive biases could help inform models of SAD as well as intervention efforts. Future research might expand on the current findings to test whether manipulating one type of cognitive bias could ameliorate another. The current findings also indicate that comorbid depression may affect cognitive biases in SAD, which underscores the need to assess and account for comorbidity in future research. Knowledge about differences between socially anxious individuals with and without comorbid depression also has important clinical implications. Different cognitive biases might be targeted in treatment depending on the presence of comorbidity, which might facilitate more effective intervention efforts.

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